The atmospheric pathway between Atlantic Multidecadal Variability and European summer in a climate model

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1. Motivation

The Atlantic Multidecadal Variability (AMV) and European surface air temperature (SAT) in summer (June-July-August, JJA) are related on multi-decadal time scale (Fig. 1) (Sutton and Hodson, 2005).

However, the question is
1) What is the **atmospheric pathway** between AMV and European summer climate?
2) Can we simulate the observed atmospheric pathway in a climate model?

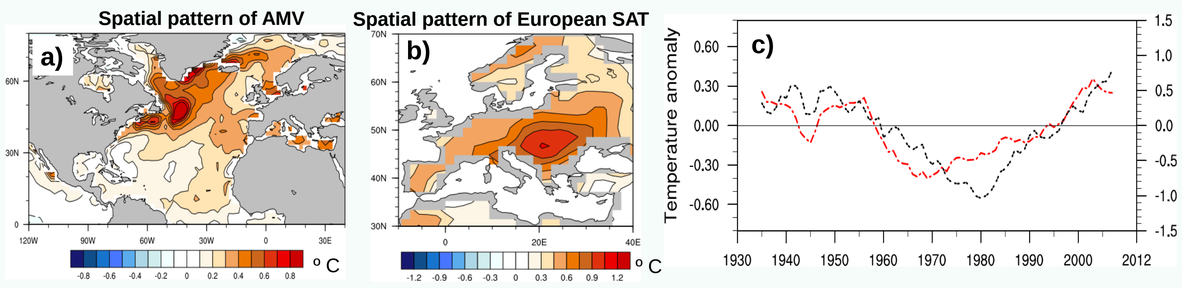

Fig 1. a) *Spatial pattern of the observed summer positive phase of AMV, defined as the composite difference of SST with respect to AMV index.* ***b)*** *the spatial pattern of the SAT over Europe in summer corresponding to the positive phase of AMV.* ***c)*** *The time series of the 11 year running mean averaged SST over the North Atlantic Ocean within the latitude 35ºN – 50ºN (red curve, AMV index) and the 11 year running mean averaged SAT over the region 40ºN-55ºN and 10ºE-30ºE in Europe (black curve). Data from 20th Century reanalysis (Compo et. al. 2011).*

Using 20th century reanalysis data as a proxy of observations, we have shown that the **observed atmospheric pathway** is established by a **North-Atlantic-European East West (NEW)** mode (Ghosh et. al. 2016).

The NEW mode is an east-west wave-like response in sea level pressure (SLP), which originates as a linear baroclinic response from the diabatic heating of the extra-tropical North Atlantic Ocean (Hoskins and Karoly, 1981) (Fig. 2).

The NEW mode affects the European climate by advecting warm moist air over the north-western Europe and by favoring European blocking situation over the central to eastern Europe (Ghosh et. al. 2016).

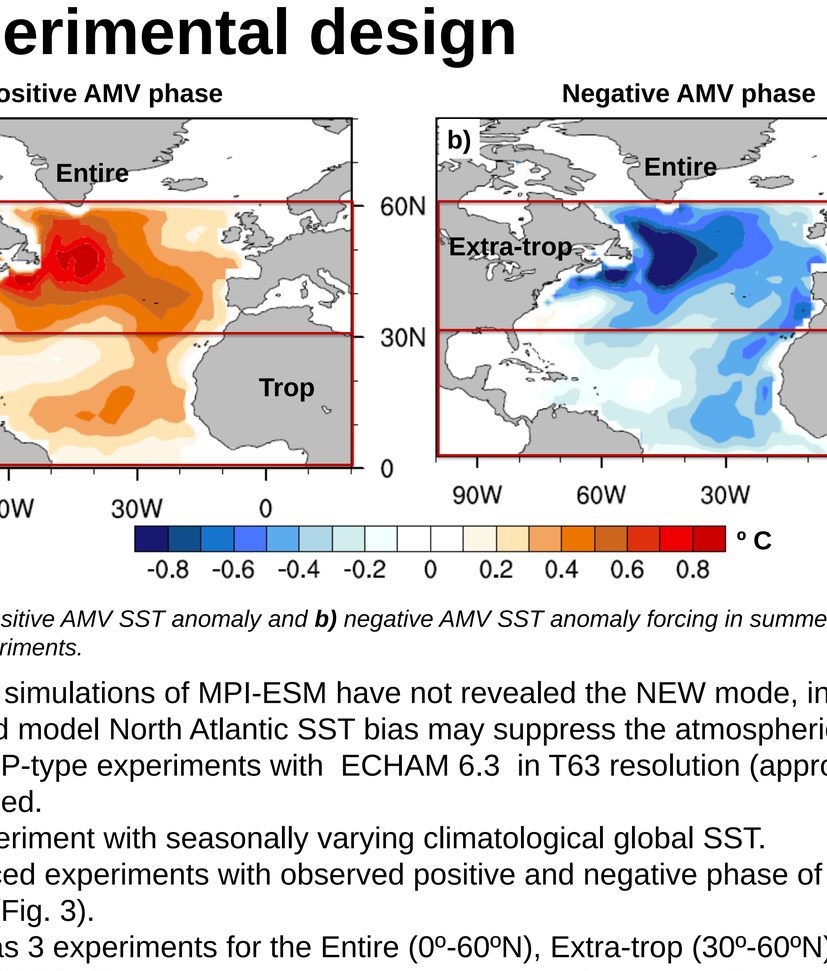

Fig 2. *The composite difference of the sea level pressure (SLP) in summer with respect to the AMV index. The pattern shows east-west wave-like structure. The region indicated by red circle shows positive heat flux anomaly in the positive phase of AMV.*

2. Experimental design

Fig 3. *The* ***a)*** *positive AMV SST anomaly and* ***b)*** *negative AMV SST anomaly forcing in summer for the AMIP-type experiments.*

- ❑ The control simulations of MPI-ESM have not revealed the NEW mode, indicating that coupled model North Atlantic SST bias may suppress the atmospheric response.
- ❑ Hence, AMIP-type experiments with ECHAM 6.3 in T63 resolution (approx. 200 km) are performed.
- ❑ A base experiment with seasonally varying climatological global SST.
- ❑ 2 set of forced experiments with observed positive and negative phase of AMV SST anomalies (Fig. 3).
- ❑ Each set has 3 experiments for the Entire (0º-60ºN), Extra-trop (30º-60ºN) and Trop (0º-30ºN) AMV SST forcing and each experiment is performed for 50 years.

3. Results

3.1 Summer SAT response over Europe

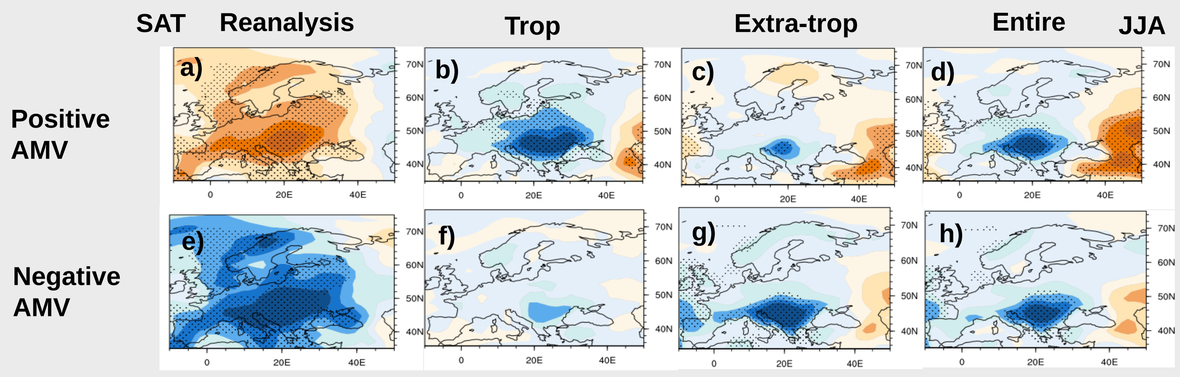

Fig 4. *The summer SAT response over Europe in the positive AMV phase for* ***a)*** *reanalysis and for the* ***b)*** *Trop,* ***c)*** *Extra-trop and* ***d)*** *Entire experiments.* ***e)*** *to* ***h)*** *are the same but for the SAT response negative AMV phase SAT .*

The SAT response over Europe in the positive AMV phase is opposite to the reanalysis (Fig 4.a,d). The SAT response is originating from the tropical branch of positive AMV SST (Fig 4.b).

The SAT response over Europe in the negative AMV phase is similar to the reanalysis (Fig 4.e,h). The SAT response is originating from the extra-tropical branch of negative AMV SST (Fig 4.g).

3.2 Atmospheric pathways for the SAT response

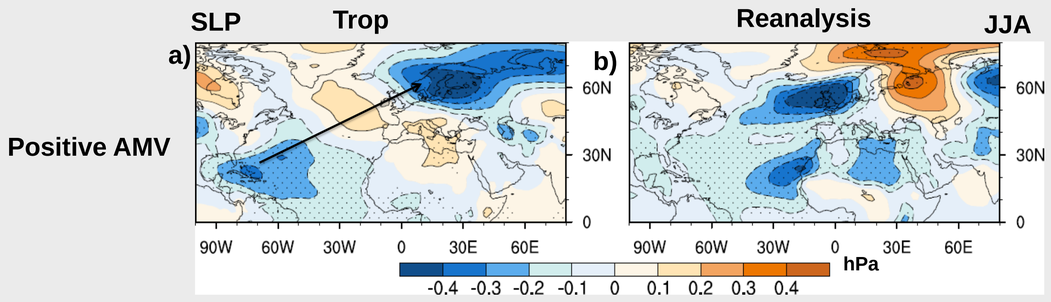

Fig 5. *The summer SLP response in the positive phase of AMV SST for the* ***a)*** *Trop experiment and* ***b)*** *in the Reanalysis*

Positive phase atmospheric response has no similarity with the positive phase response in the Twentieth Century reanalysis (Fig 5.a, b).
Model response indicates mainly a stationary Rossby wave response from the tropics

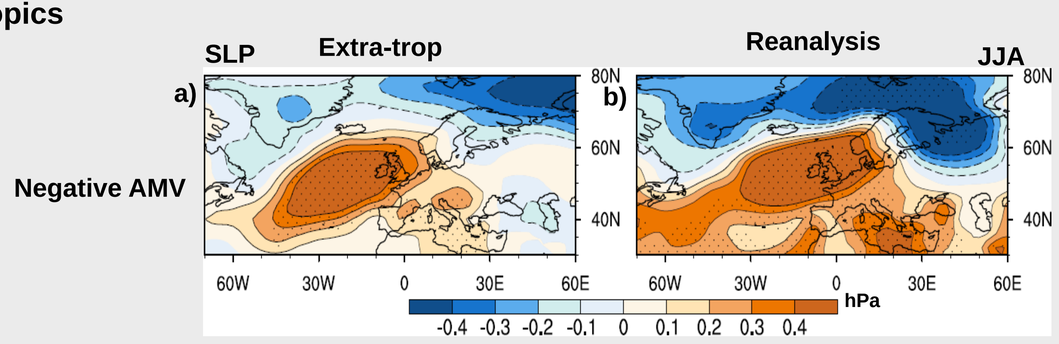

Fig 6. *The summer SLP response in the negative phase of AMV SST for the* ***a)*** *Extra-trop experiment and* ***b)*** *in the Reanalysis*

Extra-tropical negative AMV phase response closely resembles with the negative AMV phase SLP response in 20 century reanalysis (Fig 6.a, b).
ECHAM 6.3 simulates the observed atmospheric response in the negative AMV phase.

4. Summary

- ❑ In the **positive AMV phase**, the **SAT response over Europe** in ECHAM 6.3 is **opposite to the observations.**
- ❑ In the **positive AMV phase**, the ECHAM 6.3 is **sensitive to the tropical AMV SST anomalies.**
- ❑ In the **negative AMV SST phase, the observed atmospheric pathway** between AMV and European summer climate **can be simulated by ECHAM 6.3 LR.**
- ❑ In the **negative phase**, the **dominant response** is from the **extra-tropical AMV**, which **resembles the observed linear baroclinic response.**

References

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